

Effect of Feeding by *Armina californica* on the Bioluminescence of *Renilla koellikeri*

BY

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THE BIOLUMINESCENCE of the sea pansy (*Renilla koellikeri* PFEFFER, 1886) has been extensively studied in the past two decades (HARVEY, 1952; JOHNSON, 1955; CORMIER, 1961; etc.). Most of the published information treats of chemical analyses of the bioluminescent substance produced by *Renilla* when stimulated. Observations on the behavior of the living animal were performed to supplement the chemical information, and indicated that *Renilla* exhibits a general pattern of yellow-green bioluminescence that is confined to the rachis, but is able to be elicited by stimulating any part of the animal. The pattern varies between a local glow, a wave passing across the entire rachis, or a general throb, depending on the intensity of the stimulation. Under the control of the nerve net, the reaction shows an apparent pattern of facilitation, with increased stimulation causing increased bioluminescence. Waves simultaneously elicited from two different parts of the *Renilla* will dissipate when the nerve impulses meet, rather than continuing across the entire rachis.

The slime that bioluminesces is apparently produced by the animal even when the response is inhibited by an external light source. Such a light source will inhibit that part of the rachis that is exposed to it without affecting the other side of the rachis, indicating a factor other than nerve net conduction in the production of the bioluminous response. Recovery of inhibited bioluminescence follows the Bunsen-Roscoe Law.

Observers have mentioned (LANCE, 1961; RICKETTS & CALVIN, 1962) that *Armina californica* (COOPER, 1862) will feed on *Renilla*, but I was unable to find in the literature any details about the feeding patterns. Therefore I conducted a group of experiments to determine whether the feeding of *Armina* on the *Renilla* would effect any special behavioral responses on the part of the prey.

First, general observations were made of their interspecific behavior; second, a special experiment was performed to determine whether the feeding of *Armina* would cause a bioluminescent reaction on the part of the

Renilla; and, finally, a simple experiment was devised to determine whether the body juices of the *Armina* would produce an inhibitory or an enhancing effect on the wave of bioluminescence.

METHOD

For the first experiment, the method was just general observation of *Armina* feeding on *Renilla*. The animals were in a tank through which fresh sea water was constantly running.

The second experiment was to test the hypothesis that the *Renilla* would give a bioluminous response when the *Armina* feeds on it. One animal of each kind was placed in a bowl with the other. The bowl contained sea water and a sandy bottom to better simulate their natural environment. Observations were made in the dark, with sufficient light only to see the position and behavior of the two animals, but not enough to inhibit the bioluminescence of the *Renilla*. Control experiments were also performed, with a *Renilla* alone in a bowl with sand and sea water, or with *Renilla* and a non-feeding *Armina* together.

The third experiment, to test the hypothesis that fluid from the *Armina* would inhibit the bioluminescence of the *Renilla*, involved macerating one *Armina* in a blender with 15 ml of sea water to aid the grinding process. This suspension was placed on the rachis of a *Renilla* with an eye dropper. Visual observation in a darkened environment would then determine if there were any differences between the part with the *Armina* suspension on it, and the part without. A stimulating probe induced the wave response and differences would be judged according to deviations from the normal bioluminescent pattern.

RESULTS

The general behavior of the *Renilla* when *Armina* feeds upon it involves a retraction of the anthocodia and mus-

cular contractions of the rachis. The bioluminescent response was tested for only in the second experiment and will be discussed there.

Under the laboratory conditions (both with a sand bottom and with only a glass bottom to the sea water tank), the *Armina* ate the anthocodia, the rachis, and the tip of the peduncle when exposed. Further experiments should be performed to determine preference habits of the *Armina* for these various parts of the *Renilla*, and how the *Armina* senses the presence of the *Renilla*.

The results of the second experiment were that every time the wave response was elicited from the *Renilla*, the *Armina* was feeding on it. There were times during the 15 trials when the *Armina* was ingesting the *Renilla*, but without stimulating the wave response. Often the flashes would occur in rapid sequences of 6, 8, 10 or more waves. The *Armina* exhibited no avoidance behavior, as far as could be told from unaided visual observation. The *Armina* was also observed moving across the rachis, but without feeding. At these times there were no wave patterns elicited from the *Renilla*, although the rachis of the animal was curling and folding extensively.

The results of the third experiment failed to substantiate the hypothesis. No visual differences were observed between that part of the rachis covered with the macerated *Armina* and that part which was not covered by the preparation. This result did not vary, no matter how thoroughly the rachis was covered by the suspension.

DISCUSSION

There is a stimulation threshold below which the *Renilla* will not exhibit a bioluminescent response. Certain behavioral patterns of an *Armina* fall beneath this level (crawling across the rachis, righting itself after having fallen onto the *Renilla*, burrowing under the animal). The only observed behavior of the *Armina* that caused the *Renilla* to bioluminesce was feeding on any part of the animal.

Continued identical stimulation can possibly result in a raising of the threshold level necessary to produce the wave response. This would explain why a number of times the *Armina* was observed to be apparently eating, but without eliciting the wave response. Any theory that the bioluminescent reaction serves as a defense mechanism would have to account for this lack of behavioral response.

From the third experiment one must conclude (tentatively) that the *Armina* possesses no chemical substance that will inhibit the bioluminescence. The hypothesis had been that such a chemical may exist as a narcotizing agent. More refined measurements of the biochemistry of *Armina* could result in either a verification or a nulli-

fication of the conclusion drawn from this segment of the experiment.

SUMMARY

When *Armina* feeds on *Renilla*, it will elicit a bioluminescent response which other behavior patterns will not evoke. The body fluid of *Armina* seems to have no effect on the bioluminescence. Other reactions of the *Renilla* include muscular contractions of the rachis and retraction of the anthocodia. *Armina* will feed on any part of the *Renilla*.

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